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STANDARDIZATION OF MUZZLE BLAST OVERPRESSURE MEASUREMENTS

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April 1980

US ARMY ARMAMENT RESEARCH AND DEVELOPMENT COMMAND
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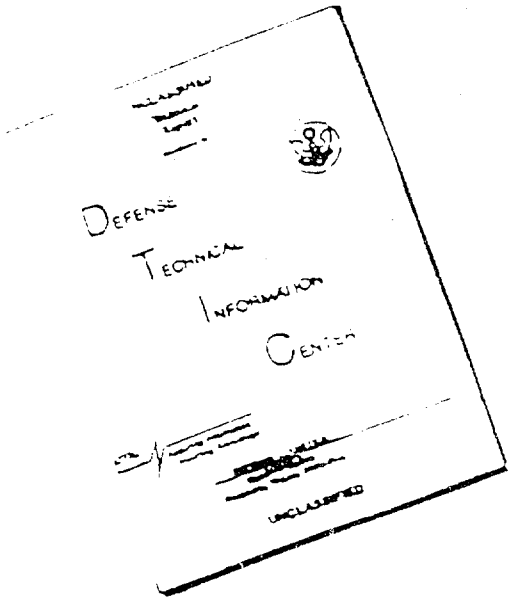

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This report details the findings and recommendations of the working group concerning test procedures, instrumentation, and reporting guide for muzzle blast overpressure measurements. The recommendations will enable test directors to correlate data at different sites of proof testing.

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REPORT

OF

The Working Group for the Standardization of Muzzle
Blast Overpressure Measurements
December 4 - 6, 1979

The Ad Hoc Sub Group for Blast Overpressure
of the Army Science Board

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I. INTRODUCTION

Reference is made to: "Memorandum for Dr. J. Ernest Wilkins, Jr., Chairman, Army Science Board". Subject: Terms of Reference for Blast Overpressure Ad Hoc Sub Group. Dated 14 November 1979 and signed by Percy A. Pierre, Assistant Secretary of the Army.

In response to the referenced memorandum a meeting was held at the U.S. Army Materiel Systems Analysis Activity (AMSAA), Aberdeen Proving Ground, MD, on 26 November 1979. This meeting was called by Dr. Ben Cummings, AMSAA and Mr. George Kahl, BRL to discuss the Army Blast Overpressure Program in general and the M198 155 mm Howitzer blast overpressure problems in particular. A list of the attendees at this meeting is attached. During this meeting Dr. George Kahl appointed a working group to review the instrumentation techniques and procedures currently employed in the measurement of blast overpressure in the Army, to propose standardized techniques for future use, to evaluate existing data on the M198, and to make recommendations regarding additional blast overpressure testing that might be required or desirable for the M198. The members appointed to this working group were:

George Coulter	BRL	A283-4911
Scott Walton	MTD	A283-2313
Joel Kalb	HEL	A283-3265
Ed Gion	BRL	A283-2914
James Patterson	USAARL	A558-4408
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II. BACKGROUND

The blast overpressure fields around artillery weapons, as a result of muzzle blast, are quite complex. Various components of the total blast wave can arrive at a particular point in space from a number of directions over and above the muzzle location itself. Blast wave reflections can be generated by the muzzle blast reflecting from the ground plane, the gun carriage, trails, fragment shields, or other nearby vehicles. All of these various reflections might arrive at various locations such as within the crew area at different times and from different directions. The problem can be further complicated by variations in muzzle brake and gun tube elevation (QE).

During the 26 November 1979 meeting MAJ Leibrecht, U.S. Army Medical Research and Development Command (USAMRDC), stated that the blast parameter of interest to the Surgeon General was side-on or incident

blast overpressure. Because of the multi-directional nature of the complex waveform resulting from muzzle blast, particularily in potential crew areas, an overall incident pressure-time history measurement is not possible. No pressure transducer exists which can make such a measurement. The best that can be hoped for is that one could predict the direction from which one might expect the highest incident overpressure and position transducers to record that pressure.

Extreme care should be taken in the necessary judgement of major blast wave propogation direction for each measurement and particularly for those families of weapons which have multiple sources of "muzzle" blast such as recoilless rifles and rocket launchers.

M198 MUZZLE BLAST MEETING

26 November 1979

NAME	ORGANIZATION	PHONE NUMBER
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III. PROPOSED STANDARDIZED TECHNIQUES

The proposed standardization of test procedure for the measuring of the muzzle blast from a weapon is given in this section.

A. Test Layout and Measurements

1. A dedicated test series should be provided for the measurement of blast pressures due to muzzle blast.

2. The transducer locations will be placed radially around the weapon with the muzzle placed at the transducer grid center (0.0) with the tube as nearly horizontal as possible. The 0° - 180° line will coincide with the axis of the barrel of the weapon in a plan (top) view, with the line-of-fire in the 0° direction. Special attention should be given to detail in mapping at the crew location.

3. A minimum of nine rounds will be fired, three each at the minimum useful elevation, the maximum useful elevation, and at an elevation midway between the minimum and the maximum.

4. All mapping transducers will be mounted at a height (to center of sensitive element) of 1.524 m (60 in.) for a standing crew man or 0.80 m (31.5 in.) for a crew man in sitting position.

5. A control transducer shall be located at ground surface on the 135° or 225° radial at a ground distance of 100 calibers measured from a point directly under the muzzle with the tube as nearly horizontal as possible.

6. All mapping transducers will be aligned with the plane of the sensitive element passing through the axis of the barrel of the weapon, thereby measuring at grazing incident to the blast wave. The sensitive element will be up. The intent is to measure the side-on pressure from the primary wave and any secondary explosions (such as those caused by unexpended propellant or detonatable gases outside the muzzle) which occurs along the axis of the barrel. This technique will tend to minimize the arrival of shock waves at transducer incidence angles between 0° and 90° where overshoot and ringing might occur.

7. Test site ambient conditions of atmospheric pressure, temperature, wind velocity, and wind direction at each firing time will be recorded.

8. Measurements shall not be made at wind speeds above 19.3 km/h (12 mph).

9. Best test practices will be used, i.e., transducers should be isolated from ground, shock-mounted, flash/thermal protected, and operated within the specified ambient temperature ranges. Cables should be protected from the blast (in conduit or buried) and run from the transducers away from the direction of propagation of the blast wave. Long lines should not degrade rise time of records.

10. For interior measurements (such as inside self propelled guns or tanks) made where the blast direction is uncertain (or arriving from many directions) the transducer shall be oriented with the sensing surface up, and with the plane of the sensing surface intersecting the center of the major suspected source, i.e., muzzle or open hatch.

B. Transducer Specifications

The transducers to be used for obtaining pressure - time data from the muzzle blast of a weapon shall meet these requirements:

1. The resonant frequency shall be 75 kHz or greater.

2. If the transducer does not have DC response the time constant will be a minimum of 200 ms.

3. The nonlinearity will be 3% or less of the full scale output of the transducer.

4. The transducer shall be chosen to minimize the effects of temperature at the expected temperature range to be used. Output will be corrected from temperature versus sensitivity curves for the individual transducer.

5. The sensitive element shall have a diameter of 6 mm (0.25 in.) or less. Transducer holders or housings should be of a minimum size to mount securely and to incorporate good aerodynamic design so as to minimize interference to the flow over the sensor surface.

6. The acceleration sensitivity will be not greater than 0.014 kPa/g (0.002 psi/g) in the axial direction and not greater than 0.069 kPa/g (0.01 psi/g) in the transverse direction.

C. Transducer Calibration

1. All transducers will be calibrated in a manner consistant with the transducer's time constant, i.e., sinusodual pressure generator, pulse calibrator, dead weight tester, or shock tube.

2. All calibration methods used will be traceable to the National Bureau of Standards.

D. Recording Equipment Specifications

1. Recorders will have a frequency response of DC to 40 kHz or greater as defined by Inter-Range Instrumentation Group (IRIG) standards.

2. FM tape recorder reproduce amplifier output filters will be operated in the linear phase mode.

3. The Data acquisition system will provide a minimum of 25dB signal-to-noise ratio for finally processed data.

E. Data Processing

1. Data will be played back through a low-pass 40 kHz filter of the Bessel type, 36dB/octave rolloff.

2. The digitizing rate shall be a minimum rate of 160,000 samples/sec.

3. All data will be scaled to standard conditions of atmospheric pressure (101.35 kPa) and temperature (288° K) with Sach's scaling laws. The standard values scaled from the measured data (superscript (h)) are found as:

$$\text{peak pressure,} \quad P_s = P_s^{(h)} \left(\frac{101.35}{P_o^{(h)}} \right) \quad ;$$

$$\text{duration,} \quad t = t^{(h)} \left(\frac{P_o^{(h)}}{101.35} \right)^{1/3} \left(\frac{T_o^{(h)}}{288} \right)^{1/2} \quad ;$$

$$\text{and for impulse,} \quad I = I^{(h)} \left(\frac{101.35}{P_o^{(h)}} \right)^{2/3} \left(\frac{T_o^{(h)}}{288} \right)^{1/2} \quad ,$$

where the subscript (o) is used for ambient conditions.

4. Analog to digital converter shall have a 10 bit word size or greater.

F. Data Report

1. The data report will present only pressure-time data scaled to standard conditions.

2. SI units will be used with dB's or psi added where needed.

3. Representative pressure-time traces will be included in the report with an exact description of how peak pressure values were obtained from the data.

4. A block diagram of recording-data system will be given including manufacturer, type, and model number of each component of the system.

5. A detailed description including serial number, model number, etc., of all components of the weapon system test along with type and lot number of projectiles and charges will be included. This description will be sufficiently detailed as to allow a complete reconstruction of the weapon system tested.

IV. EVALUATION OF DATA AND TECHNIQUES

During the course of the working group meeting on 4 - 6 December 1979, the existing data regarding M198 muzzle blast overpressures was reviewed in detail. The conclusion of the working group concerning the comparison of data acquired by different organizations was that any comparison of existing data sets was improper because the various data sets were obtained under different circumstances. The M198 data measured by the Materiel Testing Directorate (MTD) at Aberdeen Proving Ground was taken at a height of 60" above the ground surface and with a very sparse mapping pattern. The data measured by the U.S. Army Aeromedical Research Laboratory (USAARL) at Yuma Proving Ground was taken at a height of 46" above the ground and employed a much more detailed mapping pattern particularily in the crew location area. The variation in height above the ground plane could have a significant effect on the strength of ground plane reflections. Additionally the probability of very complex wave form patterns in the crew area, due to wave interactions with the various M198 components in and surrounding that area, along with the different mapping patterns, could very well account for the higher values obtained by USAARL at specific locations within the crew area. Also during the review and discussion of the data sets it was revealed that there exists a serious doubt as to the similarity of the muzzle brakes used during the two test series. There is apparently a serious question in the minds of the USAARL personnel as to whether the muzzle brake used on the M198 during the Yuma tests was of the same type and design as that currently employed. The working group concluded that the data sets are sufficiently different and therefore that comparisons should not be attempted.

The working group was advised by Dr. Patterson, USAARL, that there does exist within USAARL another set of blast overpressure data for the M198 taken at Aberdeen Proving Ground in November - December 1978 that is not yet reported. A review of the procedures and techniques used in the recording of this data indicates that it is in compliance with the proposed standardized techniques contained in this report with the exception of the availability of data on ambient temperature, pressure, and wind conditions at the time of the testing. Since however, it is the recommendation of this working group that all data be scaled to accepted standard conditions (barometric pressure of 14.7 psi and ambient temperature of 15° C) it is the conclusion of this group that the variation of actual conditions and standard conditions would have been minimized and as a result the scaling factors would not be significantly different from one (1).

Assuming that the recommendations of this working group are accepted, it would then seem reasonable to conclude that the currently unpublished data from USAARL would be an accurate and reliable data set and therefore represent the blast overpressure field around the M198. If these recommendations and conclusions are accepted there would appear to be no justification or requirement for additional testing of the M198.

V. RECOMMENDATIONS

1. If the proposed standardized techniques for muzzle blast measurement are accepted, it is recommended that they be incorporated into MIL-STD-1474B(MI), 18 June 1979.

2. It is recommended that the currently unpublished data set from the USAARL test firings of the M198 should be accepted as the reliable blast pressure field existing around the weapon when fired.

Working Group Members

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